A Database For Propagation Models And Conversion To C++ Programming Language

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1.0 Introduction

The telecommunications system design engineer generally needs the quantification of effects of the propagation medium (definition of the propagation channel) to design an optimal communications system. To obtain the definition of the channel, the systems engineer generally has a few choices. A search of the relevant publications such as the IEEE Transactions, CCIR's, NASA propagation handbook, etc., may be conducted to find the desired channel values. This method may need excessive amounts of time and effort on the systems engineer's part and there is a possibility that the search may not even yield the needed results.

To help the researcher and the systems engineers, it was recommended by the conference participants of NASA Propagation Experimenters (NAPEX) XV (London, Ontario, Canada, June 28 and 29, 1991) that a software should be produced that would contain propagation models and the necessary prediction methods of most propagation phenomena. Moreover, the software should be flexible enough for the user to make slight changes to the models without expending a substantial effort in programming. In the past few years, a software was produced to fit these requirements as best as could be done. The software was distributed to all NAPEX participants for evaluation and use, the participant reactions, suggestions etc., were gathered and were used to improve the subsequent releases of the software.

The existing database program is in the Microsoft Excel application software and works fine within the guidelines of that environment, however, recently there have

been some questions about the robustness and survivability of the Excel software in the ever changing (hopefully improving) world of software packages.

2.0 The Propagation Database

"1 he Propagation Model Database described here creates a user friendly environment that makes using the database easy for experienced users anti novices alike. The database allows sufficient freedom for users to custom fit the propagation phenomena model of interest to their requirements. 1 he database is designed to pass data through the desired models easily and generate relevant results quickly. '1 he database already contains many of propagation phenomena models accepted by the propagation community and every year new models are added to it. Only minimal computer operations knowledge is necessary to run the database.

'1 he major sources of models included in the database are the NASA Propagation Effects Handbook or the CCIR publications, sometimes they are taken from other publications such as the IEEE Journal etc. Every model included in the software contains a reference to the document from which the model was obtained, and if desired, a brief description of the model itself can be brought up on the screen or even printed. Also, when applicable, the related model names to the active model are also indicated. '1 he parameters of every model in the database are shown explicitly, anti the units of the parameters are defined completely so that the user does not have to it-west time investigating them. Wherever possible, to make the use of the model obvious to the user, default values of the parameters are given. The default values are generally values that are used most frequently with the model, the user is free 10 change them to more appropriate ones for their own case. One possible use of the default values is to compare the already known results using the default values with the newly obtained values in an experiment.

Sometimes a propagation phenomenon model may have many formulas, numbers generated by one formula are used by the next, and so on until the final result is generated. In such cases, lo include them as single step models in the database would make their usc and understanding quite: difficult, if not

impossible. To avoid this inconvenience, such models are broken down into several logical steps as appropriate, and paran walers as well as outputs of each step are described in detail one step at a time. The software makes usc of the extensive charting capabilities offered by the Microsoft E xcel software to produce charts for the model under use and the users can use these charting capabilities to change any attribute of the produced chart. Where feasible, the actual charting process is made transparent to the user and involves the user only when a choice must be made between the possible inputs or outputs.

The database also allows the user to make changes, within some guidelines, to the model being run. 1 he main restriction is that the user may make changes in mathematical functions and operations used in the model using only already existing input parameters of the model; no new definitions of parameters will be permitted. In general, this restriction is a reasonable restriction and the user can test slight variations of the existing model generated by utilizing different mathematical function and operations than the original model.

E “very model in the database has the same oper sting procedure and instructions, thus the user needs to learn the procedure for only one model in order to use the entire database effectively. All the necessary precautions to ensure the correct use of the database are incorporated in the program. When incorrect inputs are made or when an action conflicts with the general directives of the model at hand, the user is alerted with a warning, and where possible, suggestions are made to correct the input.

User friendly procedures are used to call the available mathematical functions of Excel software, such as curve fitting, statistical analysis, etc. “1 his allows the user to apply these functions to the data whenever needed.

3.0 **Software for the Propagation Database**

In the early stages of the software development, a study was conducted to evaluate the advantages and disadvantages of currently available compiler-based program versus spreadsheet program for hosting the propagation database

software. The results of this study indicated that between the spreadsheet / database software and the compiler based software available then, because of its very nature of dealing with data in columns without extra effort, the spreadsheet software can easily create a product such as the Propagation Models Database.

Of the many commercially available spreadsheet programs at that time, Microsoft Excel was selected to host the Propagation Models Database. Excel provides an extensive list of the database and mathematical functions necessary to implement the propagation models. Excel also has excellent charting capabilities that include many versions of two-and three-dimensional charts, which can be easily used or automated using the macro language. Excel also offers the dialog box utility, which can be effectively used for input and output functions of the Propagation Models Database. Another notable advantage of Excel is that it can call any executable programs written in C, which is a compiler-based program. This arrangement is ideal because it combines the advantages of a spreadsheet environment with the speed of the compiler-based software for number-crunching purposes,

The reverse of the above statement is also true, i.e., if the Propagation database were to be developed in the C programming language, it could use the Excel functions such as charting etc. to make the C programming easy. At this particular point in time, the C language has developed and evolved such that it has an extensive array of functions and interfaces that can be used to produce the Propagation Database easily. The only thing missing in the C compiler is the 'visual' effect the Excel software can produce for the inputs and outputs of the program. This need is served by the C++ programming language. C-I+ can be considered as a superset of the C compiler language and has the capability to invoke the windows and table structures which are absolutely needed for the Propagation Database.

The C++ based Propagation Database program will not run faster than the currently Excel based program. The speed increase could be as much as 20 to 50 times depending upon the operation (model) being run, In any case, there will be a general increase of speed for all operations. Another advantage of using C++ as the underlying programming language for the Propagation Database is that once the program is completed, the user does not need the C++ compiler to

run the program. This results in less cost for the user to run the program (does not need to buy the Excel software) as well as the integrity of the program can be preserved because only the compiled code of the program will be distributed to the users.

The C++ may be interfaced with the windows as well as the Excel, and when the later interface is invoked, it can pass the data to Excel program easily and also can use the functions of Excel software to plot and row / column management. This allows the C++ to use Excel's excellent charting routines and this reduces the requirements on the programmer to write the charting routines. The only downside of this arrangement is that the user must also have the Excel software along with the Database Models program. One advantage of the C++ language worth mentioning is that one has complete control over the windows and table creation and hence can create any desirable window forms.

The software Excel 4.0 was a complete program serving almost every programming need of the user, nevertheless, recently Microsoft changed its underlying language from the Excel macro language to' Microsoft Visual Basic thereby producing Excel 5.0. This was done to enhance Excel's usability as well as to increase the functionality necessary to make the input / output easy and intuitive, Even though, the step was almost necessary to compete favorably with other similar products in the market place, a converter from the older Excel 4.0 macro language to the newer Excel Visual Basic program was not provided. Even though the Visual Basic Excel (Excel 5.0) could run the older Excel 4,0 programs, any change in the macros is not supported in Excel 5.0 and the windows structures etc. are entirely different in the two languages. This meant that the programmers who created the older programs using Excel 4.0 were faced with the conversion from Excel 4.0 to Excel 5.0 if they desired to use the functionality of the newer Excel. This prompted the authors to search for a more lasting programming language, which may change in incremental steps (like all programming languages do) but not in quantum steps so that a new programming effort will be needed for the same program. Visual C++ compiler seems to fit this need.

The C++ being an Object Oriented Language, various objects may be created independently of other objects. This trait will be useful in putting the software (a

bunch of independent objects) on a network, where the remote user may be able to download either the entire software or only the desired objects and provide the input / output interface necessary for it to run. This is in addition to the distribution of the software via floppy disks through NAPEX participation. The authors feel that this method of creating the Propagation Models Database will have much greater use in the propagation community.

The current effort is converting the older Excel 4.0 based Propagation Models Database program to the visual C++ compiler based software.

4.0 **Software and Hardware Requirements**

It is anticipated that when the C++ based Propagation Models Database is released, to run it, the user may require Microsoft Windows 95 or Windows NT. Windows 95 is almost becoming a standard and Windows NT is the future of Microsoft Windows, so basing the program on any one of these systems should not cause any problem for the user. Even though the 80486 microprocessor could run the program, it is strongly suggested that a Pentium microprocessor based computer be used, At least 8 Mbytes (preferably 16 Mbytes) of RAM are required to run the software. The clock speed should be at least 50 MHz.

The C++ development is currently done using the IBM compatible PC's and not the Macintosh computers. Later on, once the software is ready for PC's the development will focus on the conversion of the software for the Macintosh computers.

It is recommended that a color monitor be used so that the charting can be done more effectively. Also, needed is a hard disk with at least 5 megabytes of storage space available for the software.

5.0 The Propagation Database

The Propagation Database is divided into six categories: the Ionospheric models, the Tropospheric models, the Land Mobile Systems models, the Effects of Small Particles models, the Rain models, and the Radio Noise models. These six categories are further divided into subcategories to include all the models to be housed in the software.

Ionospheric Models:

Tropospheric Models:

Index of Refraction Profile Model, Gaseous Attenuation Model, Refraction and Fading Model, and Scintillation Model

Mobile Satellite System Models:

The mobile satellite models are subdivided into 'Land Mobile System Models' and 'Maritime Mobile System Models'.

Land Mobile Satellite System Models:

Attenuation Frequency Scaling Model, Cumulative Distribution of Fade Duration Model, Cumulative Distribution of Non Fade Duration Model, Diffusely Scattering Model, Diversity Improvement (Tree Shadowing) Model, Empirical Regression Models, Empirical Roadside Shadowing Model, Faraday Rotation Model, Fresnel Zones, Frequency Reuse Using Orthogonal Polarization Model, Raleigh Model, and Reflection Coefficient Model.

Maritime Mobile Satellite System Models:

Fading Due to Sea Reflection Model, and Interference Due to Reflection Model.

Effect of Small Particles Models:

Cloud Model

Rain Models:

CCIR Model, COMSAT Model, Global Model, Depolarization Model, and Site Diversity Model.

Radio Noise Models:

Noise Model

The access to any model is carried out using E xcel's dialog box user interface. Each dialog box is divided into six distinct areas to help the user to provide the inputs easily.

The six areas of the dialog box are described below. The first area is used to provide general information about the model selected by the user. This step describes any particular conditions required by the model, the parameter ranges as well as the number of steps the model has, and so on. The second area is used to display formulas describing the model selected. The formula can be modified by the users to a certain extent using legal expressions in Excel. Once the formula is created, the software will use this formula for the current run only. Loading the software again will bring back the original formula. The third area is the parameter definition area, where all the parameters of the model are defined appropriately. The fourth area is called the input area. l-his **area is used to acquire input parameter(s) for** the model. The fifth area is used to display intermediate or final result(s) of the particular model. The sixth area has a few buttons to help the user and to produce the output(s) of the model (or step). For some models, this area also has buttons to allow creation of a table of output values of the model as a function of the range of the selected input parameter. The following figures show the run of the CCIR rain attenuation model included in the database software.

6.0 Future of the Propagation Models Database

From the inception of the idea of Propagation Database till present, Microsoft Excel has been the underlying software. The reason for adopting Excel was that it truly offered unique capabilities of charting and scientific functionality. However, Excel has some drawbacks such as the slow executions of the program, the large memory requirement, and the need to own the Excel software by the users. Another disadvantage Excel entails is that whenever a newer version of Excel is released, such as Excel 5.0, it may not be fully compatible with the older versions such as Excel 4.0. This makes it difficult, if not impossible, **for programmers to** develop a long-term program. Having taken all these disadvantages into consideration, it was decided that future versions of the database shall be written in the visual C++ language, because this language offers some attractive qualities such as faster execution, efficient use of computer memory, and complete independence from the compiler software once the program is compiled, It also makes the program easier to be put on a network for remote user convenience.

7.0 **Conclusion**

A database of various propagation phenomena models that can be used by telecommunications systems engineers to obtain parameter values for systems design is presented. This is an easy-to-use tool and will soon be available for a PC using Microsoft C++ software under Windows environment. Macintosh version will be created soon afterwards.